

Claims

What is claimed is:

- 1 1. A micro-stencil comprising:
 - 2 a. a membrane with a receptor surface and a print surface, the print surface being
 - 3 patterned with stencil features; and
 - 4 b. a flow region through the membrane to allow a print fluid to flow from the
 - 5 receptor surface to the print surface for printing the stencil feature on a medium.
- 1 2. The micro-stencil of claim 1, wherein the flow region comprises passages from the
- 2 receptor surface to the print surface.
- 1 3. The micro-stencil of claim 1, further comprising a reservoir for holding and supplying a
- 2 print fluid.
- 1 4. The micro-stencil of claim 3, wherein the reservoir comprises a porous material.
- 1 5. The micro-stencil of claim 4, wherein the porous material comprises a material selected
- 2 from the group consisting metal, glass, quartz, polymer, cellulose, polycarbonate,
- 3 polytetrafluoroethylene, nylon, polyether sulfone, polypropylene, mixed cellulose and

4 polyvinylidene fluoride.

1 6. The micro-stencil of claim 4, wherein the porous material is coupled to the receptor
2 surface of the membrane.

1 7. The micro-stencil of claim 4, wherein a portion of the porous material is positioned
2 within the flow region.

1 8. The micro-stencil of claim 1, wherein the stencil features comprise lateral feature
2 dimensions of less than 5.0 microns.

1 9. The micro-stencil of claim 1, wherein the membrane is formed from a resilient material
2 selected from the group consisting of rubber, silicone, urethane, vinyl, acrylic and nylon.

1 10. The micro-stencil of claim 1, wherein the membrane is formed from
2 polydimethylsiloxane (PDMS).

1 11. The micro-stencil of claim 1, wherein a portion of the membrane has a thickness of less
2 than 1.0 micron.

- 1 12. The micro-stencil of claim 1, wherein the stencil features comprise an array of stencil
features.
- 1 13. A method of making a micro-stencil comprising:
- 2 a. providing a stamp with a master surface having stencil features; and
- 3 b. forming a membrane from the stamp, such that the stencil features are patterned
4 through the membrane and wherein a print fluid is capable of passing through a
5 portion of the stencil features to transfer the print fluid onto a print medium
6 surface.
- 1 14. The method of claim 13, wherein the membrane is formed by pressing a liquid material
2 between the master surface and a support surface.
- 1 15. The method of claim 14, wherein the liquid material is cured while between the master
2 surface and the support surface.
- 1 16. The method of claim 14, wherein the membrane is released from the master surface.
- 1 17. The method of claim 16, wherein the membrane is attached to a porous backing.

- 1 18. The method of claim 17, wherein the support surface is released from the membrane.
- 1 19. The method of claim 13, wherein portions of the support surface are selectively removed
2 to form passages through the support surface.
- 1 20. The method of claim 14, wherein the support surface comprises a metal.
- 1 21. The method of claim 14, wherein the support surface comprises a porous material.
- 1 22. The method of claim 14, wherein the support surface is released from the membrane.
- 1 23. The method of claim 22, wherein the membrane is released from the master surface.
- 1 24. The method of claim 22, wherein portions of the master surface corresponding to stencil
2 features are selectively removed to form channels through the stamp.
- 1 25. The method of claim 22, wherein the master surface is formed from a porous material.
- 1 26. The method of claim 13, wherein a portion of the stencil features have lateral dimensions
2 of less than 5.0 microns.

3 27. The method of claim 13, wherein the membrane is formed from a material selected from
4 the group consisting of rubber, silicone, urethane, vinyl, acrylic and nylon.

1 28. The method of claim 13, wherein the membrane is formed from polydimethylsiloxane
2 (PDMS).

1 29. The method of claim 13, wherein the membrane has a thickness of less than 1.0 micron.

1 30. The method of claim 13, wherein the stencil features comprise an array of stencil features.

1 31. The method of claim 13, wherein the stamp is formed from a material selected from the
2 group consisting of metal, glass, quartz, silicon and polymer.

1 32. A method of patterning a micro-stencil comprising:
2 a. providing a substrate; and
3 b. forming a print surface patterned with stencil features on the substrate.

1 33. The method of claim 32, comprising forming a stencil membrane on the substrate,
2 wherein the stencil membrane comprises the stencil features.

1 34. A method of claim 33, wherein forming the stencil membrane comprises depositing a
2 liquid layer on the substrate and selectively patterning the liquid layer with the stencil
3 features.

1 35. A method of claim 34, wherein the liquid layer is formed from a material selected from
2 the group consisting of rubber, silicone, urethane, vinyl, acrylic and nylon.

1 36. The method of claim 34, wherein the stencil membrane is formed from
2 polydimethylsiloxane (PDMS).

1 37. The method of claim 32, wherein the substrate is formed from a material selected from
2 the group consisting metal, glass, quartz, polymer foam, mixed cellulose, polycarbonate,
3 polytetrafluoroethylene (PTFE), nylon, polyether sulfone (PES), polypropylene, mixed
4 cellulose, polyvinylidene fluoride (PVDF) and polydimethylsiloxane (PDMS).

1 38. The method of claim 32, wherein the surface is porous with an average pore size between
2 100 microns to 30 nanometers.

1 39. The method of claim 33, wherein the liquid layer is cured to form a solid layer prior to
2 selectively patterning the liquid layer with the stencil features.

- 3 40. The method of claim 33, wherein forming a stencil membrane on the substrate comprises
4 forming a mask and etching through the mask to form the stencil features.
- 1 41. The method of claim 39, wherein the solid layer is patterned to form the stencil features
2 using a method selected from the group consisting of laser ablation, ion beam treatment,
3 electron beam treatment and reactive ion etch.
- 1 42. The method of claim 32, wherein a portion of the stencil features have lateral dimensions
2 of less than 5.0 microns.
- 1 43. The method of claim 33, wherein a portion of the stencil membrane has a thickness of
2 less than 1.0 microns.
- 1 44. The method of claim 33, wherein forming the stencil membrane comprises depositing a
2 liquid material on the substrate to form the stencil features.
- 1 45. The method of claim 32, comprising selectively patterning the substrate to form a relief
2 surface defining the stencil features.
- 1 46. The method of claim 45, comprising forming the stencil membrane, wherein forming the

2 stencil membrane comprises depositing liquid polymeric layer on the relief surface,
3 curing the liquid polymer layer and removing the cured polymer layer from the substrate
4 surface.

1 47. The method of claim 45, comprising forming the stencil membrane, wherein forming the
2 stencil membrane comprises selectively depositing a polymer material on the relief
3 surface of the substrate.

1 48. The method of claim 33, wherein the stencil membrane is released from the substrate.

1 49. The method of claim 33, wherein the stencil features comprise an array of stencil features.

1 50. The method of claim 33, comprising rendering the substrate porous.

1 51. The method of claim 50, wherein rendering the substrate porous comprises exposing the
2 substrate to a high energy radiation source.

1 52. The method of claim 50, wherein rendering the substrate porous comprise exposing the
2 substrate to a chemical etchant.

- 1 53. A system for printing micro-patterns, the system comprising:
- 2 a. a micro-stencil with stencil features;
- 3 b. a print fluid supply coupled to the micro-stencil for providing a print fluid through
- 4 the micro-stencil; and
- 5 c. a mechanism for coupling a print surface to the micro-stencil for direct transfer of
- 6 the print fluid in a pattern of the stencil features onto a print medium.
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- 1 54. The system of claim 53, wherein the micro-stencil comprises a membrane with portions
- 2 of the stencil features passing through the membrane.
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- 1 55. The system of claim 53, wherein the print fluid supply comprises a reservoir.
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- 1 56. The system of claim 55, wherein the reservoir comprises a porous material coupled to the
- 2 micro-stencil.
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- 1 57. The system of claim 53, further comprising a pressure regulator to controllably regulate a
- 2 pressure difference between the print medium and the print fluid.
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- 1 58. The system of claim 53, further comprising means to move the print medium and the
- 2 micro-stencil relative to each other.

- 3 59. The system of claim 53, further comprising means to align the print medium with the
4 micro-stencil.
- 1 60. The system of claim 53, wherein a portion of the micro-stencil comprises stencil features
2 having lateral dimensions of less than 5.0 microns.
- 1 61. The system of claim 54, wherein the membrane has a thickness of less than 1.0 micron.
- 1 62. The system of claim 53, wherein the mechanism for coupling the print medium to the
2 micro-stencil comprises a press structure.
- 1 63. The system of claim 53, wherein the mechanism for coupling the print medium to the
2 micro-stencil comprises a drum structure.
- 1 64. The system of claim 54, wherein the membrane is an elastic membrane and wherein the
2 mechanism for coupling the print medium to the micro-stencil comprises a pressurizing
3 means, whereby the pressurizing means deforms the elastic membrane towards the print
4 medium.

- 1 65. A method for building print structures comprising:
- 2 a. placing a first micro-stencil comprising a first stencil membrane with a first set of
- 3 stencil features near a substrate surface; and
- 4 b. passing a first print fluid through the first stencil membrane to transfer a first print
- 5 layer onto the substrate surface.
- 1 66. The method of claim 65, wherein the first print fluid is passed from a receptor surface of
- 2 the stencil membrane to a print surface of the stencil membrane.
- 1 67. The method of claim 65, further comprising curing the first print layer.
- 1 68. The method of claim 67, wherein the first print layer is cured by a radiation source.
- 1 69. The method of claim 68, wherein the first print layer is cured while the first micro-stencil
- 2 is near the substrate, whereby curing gases escape from the first print layer and pass
- 3 through the first stencil membrane.
- 1 70. The method of claim 69, wherein a pressure differential is controlled across the first
- 2 stencil membrane such that the pressure at the receptor surface of the first stencil
- 3 membrane is lower than the pressure at the print surface of the first stencil membrane,

4 while curing the first print layer.

1 71. The method of claim 65, wherein a pressure differential is controlled across the stencil
2 membrane such that the pressure at the print surface of the first stencil membrane is less
3 than the pressure at the receptor surface of the first stencil membrane while passing the
4 first print fluid through the first stencil membrane.

1 72. The method of claim 65, further comprising:
2 a. placing a second micro-stencil comprising a second stencil membrane with a
3 second set of stencil features near the substrate surface; and
4 b. passing a second print fluid through the second stencil membrane to transfer a
5 second print layer onto the substrate surface.

1 73. The method of claim 72, wherein a portion of the first print layer and the second print
2 layer overlap.

1 74. The method of claim 72, further comprising curing the second print layer.

1 75. The method of claim 72, further comprising aligning the first micro-stencil with the
2 substrate surface prior to passing the first print fluid through the first micro-stencil and

3 aligning the second micro-stencil with the substrate surface prior to passing the second
4 print fluid through the second micro-stencil.

1 76. The method of claim 75, wherein aligning the first micro-stencil and the second micro-
2 stencil with the substrate surface comprises aligning marks on the first micro-stencil and
3 the second micro-stencil with complimentary marks on the substrate surface.

1 77. The method of claim 65, wherein the first print fluid is selected from the group consisting
2 of a gas, a liquid and a liquid suspension.

1 78. The method of claim 65, wherein the first print fluid comprises nano-particles.

1 79. The method of claim 78, wherein the nano-particles comprise at least one material
2 selected from the group consisting of metal, semi-conductor and insulator.

1 80. The method of claim 72, wherein the second print fluid is selected from the group
2 consisting of a gas, liquid and liquid suspension.

1 81. The method of claim 72, wherein the second print fluid comprises nano-particles.

- 1 82. The method of claim 81, wherein the nano-particles comprise at least one material
2 selected from the group consisting of metal, semi-conductor and insulator.
- 1 83. A method for building a multi-layer print structure comprising:
2 a. placing a first micro-stencil near a substrate surface;
3 b. passing a first print fluid through the micro-stencil to transfer a first set stencil
4 features onto the substrate surface and forming a first print layer;
5 c. placing a second micro-stencil near the first print surface; and
6 d. passing a second print fluid through the second micro-stencil to transfer a second
7 set of stencil features onto the substrate surface and forming a second print
8 surface.
- 1 84. The method of claim 83, wherein a portion of the first set of stencil features and the
2 second set of stencil features overlap.
- 1 85. The method of claim 84, wherein the overlapping portions of the first set of stencil
2 features and the second set of stencil features form an array.
- 1 86. The method of claim 83, wherein a portion of the stencil features of the first micro-stencil
2 and a portion of the second micro-stencil comprise lateral dimensions of less than 5.0

3 microns.

1 87. The method of claim 83, wherein first micro-stencil and the second micro-stencil
2 comprise a resilient polymeric membrane.

1 88. The method of claim 83, wherein at least one of the first and the second print fluids
2 comprise an amino acid moiety.